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OBSERVATIONS

UPON

LIGHTNING,

AND THE

METHOD of SECURING BUILDINGS
from it's EFFECTS,

IN A

LETTER to Sir CHARLES FREDERICK, &c. &c. &c.

K
BY

B. WILSON, F.R.S. and Ac. Reg. Up. Soc.
and OTHERS.

L O N D O N,

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M DCC LXXIII.

OFFICE OF THE

SECRETARY

OF THE



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P R E F A C E.

THE following letter was written in consequence of a difference in opinion among the members of a committee (of which I had the honour to be one) appointed by the Royal Society, at the instance of the Board of Ordnance, to consider of, and propose, the best method of securing his *Majesty's magazines* of gunpowder at *Purfleet* from accidents by lightning.

The subject of that difference was this: whether the metal proposed for Conductors to those buildings, should be *pointed* at the top or *not*.

A Question, in my judgment, of considerable importance, as the quantity of powder lodged in those magazines, is in general so very great, that should any accident happen, from an improper construction

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tion of such Conductors, the most fatal consequences might ensue.

I therefore thought it behoved the committee to be extremely cautious in recommending *any apparatus* that was *exposed to the least hazard*. And being myself, from experiments and observations, thoroughly satisfied of the impropriety of pointed Conductors, either in *that* or *any other case*, I did not scruple to object to the method then proposed; giving at the same time *my reasons to the committee* for so doing. But yet, not without offering another method, which I believe is far less liable to objections.

The reasons for proposing another method, and the advantages to be expected from it, are fully explained in the following letter, which I took the liberty of addressing to Sir Charles Frederick, as a member of the Royal Society; who communicated the same to Dr. Maty, the Secretary: wherein he expressed the wish of his majesty's Board of Ordnance to obtain every light relative to the best method of constructing Conductors.

These

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These letters being read at the Society, *part of the committee*, at the next meeting of that learned body, signified by a letter, which was afterwards transmitted to Sir Charles Frederick, their adherence to their former opinion. But *without* summoning the rest of the committee, for the reconsideration of this matter; *without* entering into any reasons; or *without* throwing any more light upon the subject.

However, apprehending the following paper will not appear in the Philosophical Transactions for *some months*, and conceiving the nature of the subject to be of too much consequence, *at this particular time* *, to admit of delay, I am desirous to take the earliest opportunity of laying it before the public, together with some *additional notes, &c.* which I think are material: submitting the whole to the judgment of those versed in this part of philosophy; who will, I am persuaded, bestow on it all

* See the letter from Sir Charles Frederick, which expresses a desire to have the letter read as soon as it could be done with convenience; it being on a subject very interesting to his majesty's Board of Ordnance.

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P R E F A C E.

the consideration and attention that so important a subject deserves.

It is with regret I find myself obliged to differ from one who has so much merit in electric enquiries as Dr. Franklin. But I trust that no man of candour will be offended with my entertaining and expressing my own thoughts; especially in a matter of so much consequence.

I have been favoured with a letter on this subject from one of the committee, Edward Delaval, Esq. which he has given me leave to insert in this publication.

March 21, 1773.

B. WILSON.

To

To Dr. MATY, Secretary to the
ROYAL-SOCIETY.

S I R,

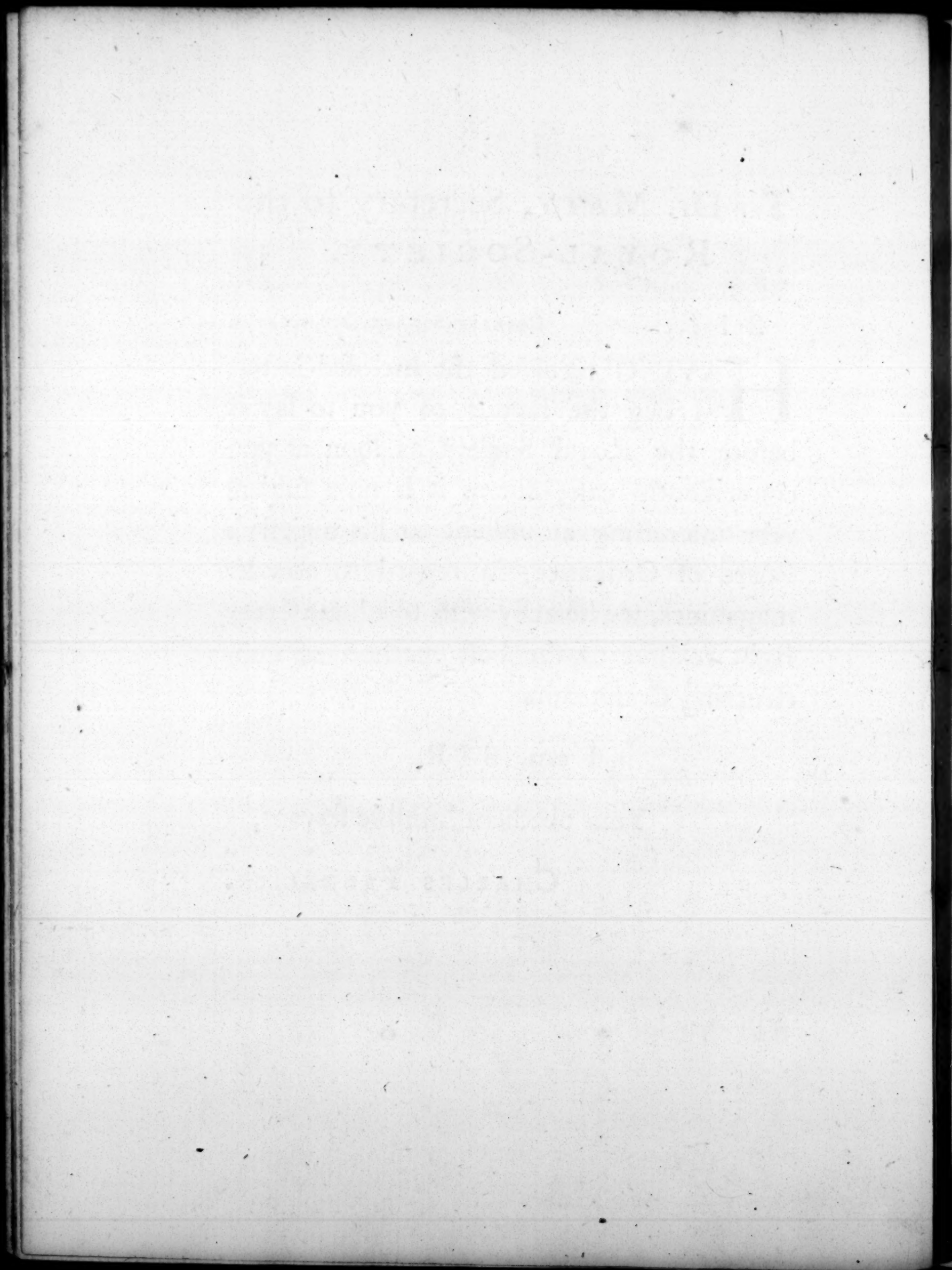
BERKLEY-SQUARE, DEC. 10, 1772.

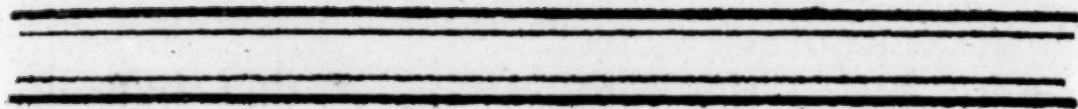
HAVING received the inclosed letter,
I beg the favour of you to lay it
before the Royal Society as soon as you
conveniently can; for as it is on a subject
very interesting at present to his majesty's
Board of Ordnance, in regard to powder
magazines, we heartily wish to obtain every
light relative to the best method of con-
structing Conductors.

I am, S I R,

Your obedient humble servant,

CHARLES FREDERICK.





ON
CONDUCTORS.

TO SIR CHARLES FREDERICK,
Es. Es. Es.

SIR,

Read at R. Society,
10 Dec. 1772.

YOUR station as Surveyor-General of the Ordnance being such, as makes the subject of this paper particularly interesting to you, I presume an apology for this address will be wholly unnecessary.

Upon an application of the Board of Ordnance to the Royal Society in July last, a Committee was appointed, to consider of the properest method for securing the *Magazine at Purfleet* from mischief by lightning; which Committee reported to the Council of that learned body what they thought necessary

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fary to be done upon that occasion. The Council afterwards transmitted to the Board a copy of that report, together with another paper written by myself in consequence thereof.

For, during the consideration of that business, some doubts having arisen in my mind, with regard to the propriety of *points*, which were proposed to terminate the top of each conductor; and those doubts being founded upon experiments and observations, I could not consistently subscribe to that report, nor suppress my opinion on a subject of such importance.

Whatever may be the sentiments of others respecting those doubts, yet they being the result of my mature consideration, I thought it my duty to propose them to the Committee; and further to express my *dissent* in writing to that particular part of their report: giving at the same time some of the principal reasons for such dissent, and referring them, for further satisfaction on this subject, to a letter which is already published in the Transactions of the Royal Society.

As that dissent is the origin of this paper, a copy of it is here inserted.

“ I dissent from the report above, in that part
 “ only which recommends, that each Conductor
 “ should terminate in a *point*.

“ My reason for dissenting is, that such Con-
 “ ductors are, in my opinion, less safe than those
 “ which are not *pointed*.

“ Every

[3]

“ Every point, as such, I consider as *soliciting*
 “ the lightning; and, by that means, not only
 “ contributing to *increase* the quantity of every
 “ actual discharge, but also frequently occasioning a
 “ discharge where it might not otherwise have hap-
 “ pened.

“ If therefore we invite the lightning, whilst we
 “ are ignorant of what the quantity, or the effects
 “ of it, may be, we may be *promoting* the very
 “ mischief we mean to prevent.

“ Whereas, if instead of pointed, we make use
 “ of blunted Conductors, those will as effectually
 “ answer the purpose of conveying away the light-
 “ ning *safely*, without that tendency to *increase* or
 “ *invite* it.

“ My further reasons for disapproving of *points*,
 “ in all cases where Conductors are judged neces-
 “ sary, are contained in a letter alluded to above,
 “ which is addressed to the *Marquis of Rocking-*
 “ *ham*, and is published in the Ph. Tr. vol. 54.
 “ p. 247.

“ There are other reasons also which I have to
 “ offer, for rejecting points on this particular oc-
 “ casion, and which *were mentioned at the Committee*.
 “ Those I shall lay before the Royal Society at
 “ another opportunity, for the benefit of the pub-
 “ lic.”

B. Wilson.

Royal Society House,
 21 August, 1772.

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Agreeable

Agreeable to the declaration at the end of the above dissent, I shall now proceed to offer my further reasons for objecting to pointed Conductors.

Experience, which is our best guide in all physical inquiries, but particularly in electrical ones, every day convinces me, that we know but little of that subtle fluid which operates so *secretly*, and at the same time so powerfully, upon the earth and its atmosphere. I confess that I am even now less acquainted with the principle of its action than I thought I was twenty years ago. The *smallest differences*, in the circumstances of our experiments, frequently causing very *material differences* in their results. And perhaps no one, who has not applied his mind closely to inquiries of this kind, could conceive how the *pointing a piece of metal or not* should make any material difference in the experiment.

The electrician has it always in his power to convince any one of the fact, who through inexperience, may be inclined to entertain the least scruple about it. For *even from those experiments*, to which it was thought proper to appeal at the Committee, it appeared, that the difference in the effects upon this fluid, between *pointed* and *blunted* metal, is as 12. to 1. *

A Thunder

* The experiments were contained in a paper, which Dr. Franklin produced and read at the Committee. There was no doubt declared by any one of the Committee, at the Time, of the difference in the effects between pointed and blunted metal being as 12 to 1. I had myself indeed experienced even a greater difference. And one principal cause for it, I apprehend, might be a
difference

A Thunder cloud therefore, according to the above experiment and inference, the circumstances of it being supposed to be nearly similar with what is called the Prime Conductor in those experiments, if it acted at 1200 yards distance upon a point, would require a blunted end to be brought within the distance of 100 yards; and beyond those limits would pass over it without affecting it at all. On this occasion permit me to observe, that the *longer* the Conductors are above any building, the *more danger* is to be apprehended from them; as they will in that case approximate nearer in their effects to those that are pointed. And that is one reason, why I was not for advising the proposed Conductors at *Purfleet* to be so high as *ten feet* above the magazines; and more particularly upon that building called the *Board-house*, which stands considerably higher than the magazines themselves.

But before we advance farther into this subject, it may be proper to shew the reasons for introducing a *pointed* apparatus, when the experiment upon lightning was *first* proposed: what good consequences were derived from that experiment: and why, upon
further

difference in the sharpness of the point I employed. For it ought to be understood in those nice experiments, and which I do not find has hitherto been noticed by any one in these researches, that a mechanical point is an *indeterminate expression*; as such points may differ greatly in the degree of sharpness, according to the nature of the material, and the ability of the workman who forms them. And a very small difference in those respects will, it is well known, make a considerable difference in the effects upon this fluid, when they are opposed properly to any body that is electrified.

further experiments and observations, such points ought now to be laid aside : when our intention is *not to make electrical experiments*, but by the means of Conductors, to *preserve buildings from the dangerous effects of lightning*.

Dr. Franklin, in his conjectures, that lightning and electricity were one and the same fluid, considered how he should *invite*, or *bring down and collect the lightning*, so as to make experiments upon it.

And he concluded from observation, that the likeliest method would be, to make use of such an apparatus for the purpose, as was most susceptible of electric effects ; or, in other words, such an apparatus as would receive the electric fluid with the greatest ease.

Repeated experiments taught him, that *metals* had the property of receiving that fluid with more ease than other substances.

He also learnt, from the like experience, that metals, *by being pointed*, were rendered still more susceptible of receiving it.

And therefore he proposed an experiment to be try'd, whether it was not in our power to invite, or bring down the lightning, by an apparatus consisting of "an *electric stand*, and an iron rod 20 or 30 feet " in length, rising upright from the middle of the " stand, and at the top terminating in a very *sharp* " *point*." This apparatus was recommended to be put upon some high building, with the expectation, that if a thunder cloud should happen to pass near this apparatus, some quantity of lightning, deposited therein,

therein, would probably be collected in the rod, by means of the very *sharp point*, and the *electrical stand* at the foot of the rod.

That this contrivance answered the end he first proposed, we have had sufficient evidence.

And it is no wonder, if after this great discovery, we find him, and other electricians, pursuing new experiments of this kind, and raising those points higher into the air, to collect still greater quantities of that fluid which occasions lightning. Nor need we be surprized, after knowing that lightning could be brought down from the heavens by so simple an apparatus, and after experiencing its subtile effects to be similar to the electric fluid, that the Americans and others, upon Dr. Franklin's recommendation, adopted the principle of securing their buildings from its mischievous effects, by raising, above their houses, rods of iron *very sharply pointed*, and applying *wires* from the lower ends of those rods, down the outside of their houses to the ground.

But though there appeared many arguments at that time in favour of such Conductors, yet experiments and observations at last, induced Dr. Franklin to *alter his opinion* in respect to those *wires*; and to substitute, in their place, *rods of iron*; still retaining the principle of having the rods at the top *sharply pointed*. And many of the Americans, as well as Europeans, approved of the alteration, as appeared afterwards, from constructing their Conductors accordingly.

About that time great attention was given, and many new experiments were made, in consequence

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of the frequent dangerous effects which lightning was observed to produce in some valuable buildings, by rending and dashing to pieces very large stones, and timbers, which were connected together by cramps and bars of iron ; and at other times, breaking and melting part of those rods, and sometimes *exploding wires*, even of a considerable thickness, like so much gunpowder.

From careful observations of these extraordinary appearances produced by violent shocks of lightning ; and upon making other experiments relating to a certain resisting power *in*, or *upon*, all bodies, which appears to act against the attacks of lightning, as well as against the electric fluid ; philosophers were enabled to assign the reason, and it is apprehended upon a solid foundation, why Conductors should be made of *metal*, in preference to all other materials : as the power of resisting such attacks is less in metals, than in wood, brick, stone, or marble.

And that this resistance might be the more simple and uniform, it appeared most eligible to have the Conductors made of *one continued piece of metal only*, and of *an equal diameter throughout*. But what that diameter ought to be, depended upon other circumstances, some of which are taken notice of in a former paper referred to above, which I laid before the Royal Society.

By this historical sketch, we see the propriety of Dr. Franklin's introducing points, and the advantage philosophy has derived from them : by ascertaining that lightning, and electricity, are one and the same fluid :

fluid: which appears to be diffused every where, at least upon *this earth* and in the *atmosphere*.

But since this important fact has been discovered, and repeated experiments had taught us, that we have it in our power to collect that fluid which occasions lightning; this manner of invitation, viz. by using points, *ought*, in my opinion, *to cease* *. Because a greater quantity of lightning than we have yet experienced, may chance to attack us.

For we are so far from knowing how great the magazine of lightning may be in the atmosphere, or in the earth, when it is ready to discharge itself, either by one, or more explosions, that we are *ignorant even of the quantity actually discharged*, whenever any stroke from lightning visits us.

Nor can the ablest philosopher *fix the limits of the greatest discharge* that may possibly happen.

Seeing then how vain it is to look for any thing like *absolute Security* in all cases; it surely behoves us *to proceed with caution*: and it is for that reason I have always considered pointed Conductors as being unsafe, by their great readiness to collect the lightning in too powerful a manner. And lest the Conductors, without such points, should be too slender for very violent attacks, in places of great consequence, I have always recommended the having them above four times larger in diameter, than what are commonly made use of.† To the end that our security may be the greater, by opening a larger
B passage

* Unless where the electrician, like *professor Richmann*, (who was killed by it,) at his *own hazard*, chuses to make further observations on lightning.

† This was the case with St. Paul's Church, when Conductors were recommended for that building.

passage for any extraordinary discharge; and so far lessening the danger to be apprehended from it.

I ought not, in this place, to omit taking notice of a paper, containing some further experiments and observations, which was produced at the Committee, to shew, among other things, that pointed metals were more disposed to receive the lightning, by virtue of a repelling principle in lightning, as well as in the electric fluid, which acted upon the *natural quantity* of the fluid contained *within part of the metal*, to a considerable distance from the *point*, causing, if I may be allowed the expression, a kind of *vacuum* therein.

So far from disputing this philosophy, I readily admit the fact.

But I am afraid, *every attempt* to prove that pointed Conductors may be so disposed to receive this fluid more readily, at the point, will not mend the argument in the least; because the more we lessen the power of resisting, (even supposing the whole Conductor in that state) the more we increase the power of invitation.

In regard to other experiments, with "*locks of cotton* * , which are acted upon in a particular manner by the apposition of points; and the conclusions drawn from thence, in favour of *pointed Conductors*, as causing similar effects upon the *fragments, or small clouds*, which hanging below the *thunder clouds*, have been supposed a kind of *stepping stones* for the lightning to pass upon towards the earth; such

* See Dr. Franklin's Experiments.

such *pointed Conductors* being *supposed* to occasion those fragments to *retire up into the cloud* from whence they were suspended ; and on that account, to prevent a stroke from lightning, which might otherwise have happened. I shall for the present wave entering into this philosophy, as I could wish the conjecture to be *reconsidered* ; because I apprehend it is liable to many objections, which to enumerate would carry me beyond the proper bounds of such a paper as this. However, if the same opinion should be again offered, and brought in argument, it may be worth while to enter more *deeply* into the enquiry.

If those gentlemen, who argued at the Committee for the *necessity of points*, could have made it appear, that such points draw off, and conduct away, the lightning *imperceptibly* and *by degrees*, *without causing any explosion*, during a thunder storm, (which seems to have been once the opinion of Dr. Franklin) I should readily have subscribed to their report.

But experience shews us, that the fact is otherwise, there being many instances, where violent explosions of lightning have happened to Conductors that were *sharply pointed*. And *three* in particular, the accounts of which are inserted in a publication of Dr. Franklin's *, where the *points* were *dissipated*, or *destroyed*, and a small part of an iron rod melted next the points of one of them ; and also at the several crooked ends of the rods below, where they were hooked on to each other, and formed the *Conductor* belonging to Mr. Maine in North America. But as those letters are long, and contain several

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other

* Dr. Franklin's Experiments, page 394, 416, 417, &c. Extracts from which are in the Appendix of this publication.

other curious facts, I shall reserve them, together with some further observations upon the *nature* and *power* of that *resisting principle*, which is found to act so sensibly against the attacks of the electric fluid, or lightning, to some future dissertation.

There is no building, that I know of, more exposed to this kind of danger, than the *Eddystone Lighthouse*, as it stands upon a rock in the sea, several miles from land. The fixing of a Conductor to that building was thought highly proper; and the fixing of a point upon it, as highly improper. It was therefore resolved upon to put up a Conductor without a point, that no more lightning might be unnecessarily solicited to the building; and that all the lightning, which accidentally fell on it, might be conveyed away without injuring it. This Conductor was fixed twelve years ago, and the building has since received no injury from lightning *.

There is another edifice of great consequence, I mean *St. Paul's church*, which stands much exposed, from its height, to accidents by lightning. The Dean and Chapter, of that cathedral, thought it an object deserving the serious attention of the Royal Society. A Committee was therefore appointed, in consequence of their application; and proper Conductors were put up in the several places where they were thought necessary, from the top of the *Lanthorn* to the *Sewers* under ground. And notwithstanding particular care was taken to have the additional metal, either of a considerable diameter,

OR

* *N. B.* A former building, erected for the same purpose upon this rock, was set on fire by lightning.

or an equal quantity of it formed into other shapes, for the conveniency of the several places, yet part of those Conductors, consisting of iron, in the *Stone Gallery*, shewed marks of their having been made *considerably hot*, if not absolutely *red*, by a stroke of lightning, which happened in March last, as appears by a letter, which I communicated to the Royal Society, from one of the Vergers of that church, Mr. Richard Gould, who had examined the Conductors the morning following, along with Mr. Burton of the same cathedral *, and that the appearances

* Mr. Gould acquaints us in his letter, that he examined the four Conductors in the lanthorn and stone gallery of St. Paul's church the morning after the lightning happened. That no marks whatsoever appeared upon the Conductor to the *South*, which was the first he attended to. That he examined next the Conductor to the *West*, and observed, " A thick rust lying upon the pavement in the stone gallery, as if it had been cleaned off, from the Conductor, with a tool: that several parts of the iron appeared black—particularly the screws or nuts: something like the effects left by gunpowder upon iron or steel; or a smoaky fire.

That the Conductor to the *North* shewed no marks, no more than to the *South*.

But that upon examining the Conductor to the *East*, he found *stronger marks abundantly*, than on the West Conductor—it being much blacker, particularly on the nuts and screws; the rust lying in greater quantities on the pavement. And the *extreme part of the Conductor that goes into the water trunk*, seemed like a piece of iron, *newly taken out of a forge* by a smith, without working it on the anvil.

N. B. Mr. Gould has since added to the account in his letter, some circumstances which I apprehend ought not to be omitted. He says, that where the end of the Conductor on the East side points towards the water trunk, a stone surrounds part of it, leaving an interval half an inch wide between them, and about four or five inches long; which is a little more than the breadth of the Conductor. That this interval was *filled up with dirt*, and had
been

ances were in general as the Verger's letter related them to me.— Mr. Delaval and I went there about *a week afterwards* to observe them, and their particular situations, with the circumstances attending them; when we were very well satisfied with his account, notwithstanding it had rained in the *interim* for three Days together.

It is worthy of note, that those *Conductors* did not *terminate* in a *point*; nor was any *point* put upon the *cross* at the top ————— and yet Dr. Franklin was of that Committee.

If points are so essential to our safety, why was not the reason enforced at the Committee, for having them on that capital edifice? For my part, I think it was a happy circumstance, that there was

no

been so for some time, occasioned by frequent showers of rain washing the pavement in the stone gallery. That after the lightning happened, he observed a *hole* was made through the dirt, *one quarter of an inch in diameter*, and about *two inches in length*. That the hole was close to the iron. And that upon stooping down his head, he perceived a very *disagreeable smell of sulphur* from the *stone, dirt, and Conductor*; particularly the last.

Upon hearing this account, Mr. Delaval and myself a few days ago went and examined the *Conductors* again; but more carefully than before: for upon causing the stone to be removed which covered the top of the water trunk, we had an opportunity of examining near two feet more of the iron *Conductor* which points to the water trunk, than we could perceive before this stone was removed. When we observed that the conducting iron *did not touch the lead*.—We likewise observed that there was a *very thick coat of rust* all over that part of the iron, particularly at the end next the lead, where the water entered the trunk.

As the necessity of attending to these circumstances will be obvious to any one who is but in the least degree acquainted with these researches, the danger of neglecting them will be seen in the strongest light by the gentlemen of the Committee, who recommended the *Conductors* for the security of that cathedral.

no point fixed upon the top of the church, to solicit a greater quantity of lightning at that moment, than what fell upon the Conductors, circumstanced as they were; as *that quantity* was great enough to heat so considerably, a *bar of iron* near *four inches broad*, and about *half an inch thick*.

This powerful effect reminds me of another instance still more extraordinary, which happened in *Martinico*, and is related by Capt. Dibden, where a *bar of iron, one inch in diameter*, was, by a violent shock of lightning, reduced in one part to the thickness *only* of a *slender wire*. See Ph. Tr. Vol. 54. p. 251 *.

Since then we are at all times ignorant of the quantity of lightning in the earth and its atmosphere: and the difference in the effects, between blunted and pointed ends, in causing a discharge in our electrical experiments, appears to be as 1 to 12. It is easy to comprehend the great danger this noble fabric has probably escaped, by having no pointed apparatus upon it.

From the above observations, I am naturally led to consider a part of the proceedings of the Committee, respecting the magazines at Purfleet: when a certain number of Conductors, with tapering points at the top, were resolved upon as necessary to protect the several buildings where the powder is deposited. For it was *agreed* upon, at the same meeting, that the Board-house, which is a large building for the use of the Board Officers, and which stands considerably higher than the magazines, as was observed

above

* See the Appendix.

above, *did not require any point at the top*; because it was apprehended to be *perfectly secure*, by reason of the copings on the roof, the gutters and pipes to carry off the water, being all of lead: and further, because those pipes communicated with two wells, which always contained water.

I was not a little surprized at this last resolution, which appeared to be so *inconsistent* with the former. Because if points were necessary in one place, they ought to be so in another. And on the other hand, if the Board-house is secure by the leaden accidental Conductors, which have no points, why ought not the magazines to be equally secure, when put into the same circumstances?

I therefore enforced the *inconsistency* of such a resolution in the strongest terms. Notwithstanding which, the gentlemen, at that time, thought proper to confirm their resolution. However, at the next meeting of the Committee, I observed that they had been pleased, in the mean time, to make an amendment in favour of points for the Board-house; which amendment was no sooner proposed, than approved of.

Why my observation was rejected at the preceding meeting, I must leave to the judgment of others. But it certainly carries an appearance, as if *manifest contradiction*, upon further reflection, must have been the *cause* of that alteration.

And I am inclined to believe, from some gentlemen of the Committee expressing their opinion, in the Committee, "*of its being a matter of mere indifference, whether blunted or pointed Conductors*
" *were*

"*were made use of,*" that they have not considered this subject, with all the attention that so important an object deserves.

For if our experiments shew, that points, from the nature of their shape, and *other* circumstances attending them, resist the attacks of this fluid less than blunted ends, and that blunted Conductors of proper dimensions are sufficient to convey away the lightning *safely*, whenever it attacks them, why should we have recourse to a method, which is at best uncertain; and which, some time or other, may be productive of the most fatal effects? *

But perhaps no argument can be brought with more force against the principle of points, than Dr. Franklin's own words, which are published in his experiments, p. 481: where he declares *positively*—
 "Buildings, that have their roofs covered with lead, or other metal, and spouts of metal continued from the roof into the ground to carry off the water, *are*
 "*never hurt by lightning*; as whenever it falls on such a building, it passes in the metals and not in the walls."

This is the case with the *British Museum*, a building also of considerable consequence, where there are no other Conductors than what are formed by the copings, gutters, and pipes, which are all of lead, and communicate with the ground. Now it

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is

* *Points* exposed for the reception of lightning are likewise *subject to this material objection*: they are meant to invite, or draw off the lightning *continually*; but we find from experience, that those sharp points are *extremely subject to be melted down and destroyed by it*: they are therefore so far rendered *useless and vain*, as no one can exactly say *what the duration, or what the effects* of any storm of lightning may be.

is from the great quantity of metal contained in the several pipes, together with the other circumstances attending them, that I considered that building, (in a former paper laid before the Royal Society) as being sufficiently secured from those dangerous effects.

But if any gentleman should be disposed to entertain a doubt about it, or indeed of any other part of my reasoning on this subject, a declaration of those doubts may be attended with good consequences, as they will necessarily open the door to a more minute investigation.

I have now gone through the reasons which I proposed to lay before the Royal Society for the *rejecting* of points; and I am very sorry in the course of this letter, to have been under the necessity of mentioning any differences in opinion, which passed between the members of the Committee, to whom this important matter was referred; I think however, I shall stand excused to the Society and the public, when it appears, as I hope it now sufficiently does, what my motive has been, namely, to state clearly, and impartially, the objections which I conceived to lie against pointed Conductors; and to disclose, *without any reserve*, the principles on which such objections are grounded.

I am, Sir,

with the greatest respect,

Your most obedient,

and most humble servant,

8 Dec. 1772.
Great Russel-Street,
Bloombury.

Benjamin Wilson.

Mr. Delaval, who was one of the Committee, has given me leave to insert his opinion upon this subject ; which is this, That he concurs with me in thinking, that such Conductors as are elevated higher than the buildings to which they are applied, or are pointed at the top, are improper and dangerous.

He was desirous of delivering his opinion at the Committee ; but as the meetings of it were held in the Summer only, his absence from London prevented his attendance.

Read at the Royal Society the
10th of December, 1772.

A LETTER

From EDWARD HUSSEY DELAVAL, Esq;
F.R.S. to Mr. WILSON, F.R.S. &c.

S I R,

FROM the Report of the Committee appointed by the Royal Society, it appears that pointed Conductors were recommended to secure the magazine at Purfleet, from the effects of lightning: But as I find, from your Dissent, which accompanies that Report, that in conformity to what you had formerly advanced, you apprehend that such Conductors are dangerous; and as my absence from town prevented my attendance on the meetings of the Committee, which were held during the vacation, I think it incumbent upon me to comply with your desire of giving my opinion on this subject, and the reasons on which it is founded.

The question seems to amount to no more than this, Whether it be proper to use pointed Conductors, which invite or facilitate the entrance of lightning into buildings, in preference to blunted ones, which have not the like power of soliciting it?

I believe every one will now admit, that pointed Conductors are indued with a power of drawing lightning from the clouds; as it was from this theory

theory that the first experiments were made, and the succeeding ones have constantly confirmed it.

If it is the opinion of any one, that the invitation of so formidable an enemy is desirable, it must, I imagine, be founded on a supposition, that all the electrical contents of the impendent cloud, can be completely and instantaneously carried off through so narrow a channel, so as to be no longer capable of acting upon the intermediate parts of the building.

But I believe this supposition will not appear agreeable either to reason or experience, when we consider that clouds of a dimension equal (as Dr. Franklin judiciously supposes) to * ten thousand acres, are frequently fully charged with the matter of lightning; and that although lightning † “strikes” the highest and most pointed objects in its way, “preferably to others, as high hills, and trees, “towers spires, masts of ships, &c”, which therefore must be looked upon as Conductors; yet in this city, notwithstanding no place furnishes a greater number of these elevated and pointed objects, the collective power of all of them, in draining the impendent clouds, is constantly found insufficient to defend even the *lowest parts of the city from being injured.*

This appears, not to mention other instances, from the effects of the lightning in Essex-street on June 18, 1764, at the same time that St. Bride's church was so greatly damaged.

Nor

* Franklin's Exp. p. 65.

† Priestley Hist. Elec. p. 175.

Nor were the Conductors of St. Paul's church able to defend the chapel in Tottenham Court Road, which appears to have been struck nearly, if not exactly, at the same time with that cathedral, on March 22, 1772.

If the united power of so many Conductors, as are contained in and about this large city, are insufficient to deprive the impending cloud of its contents, how then can we expect so great an effect from so narrow a channel as one or two small Conductors can afford.

If this be rightly stated, the intention of draining the contents of such immense bodies by such small conveyances, is entirely frustrated; and we can no longer assign that, as a reason for inviting the lightning from them into such buildings as we mean to secure.

It is true, that a blunted Conductor will receive a spark from a body charged with the electric fluid at a greater distance than a pointed one will; but, on the other hand, a *pointed* one will receive the *greater quantity, and with a greater facility*: the *spark*, which is visible when the blunt body is used, is a sign that the electric matter finds a *difficulty in entering* that Conductor.

No argument can be drawn from hence in favour of points, the object in view not being to guard against the *appearance* of the lightning, on its *entering the top of* the Conductor, but to prevent the damage which will arise from *too great a quantity after it has entered* the Conductor, or any other part of the building; and it cannot be denied, that pointed and elevated rods of metal will receive from the clouds

clouds a greater quantity, and with less resistance, than such as are blunted.

When a small wire, with its ends blunted, is interposed between the inside and the outside of a large jar properly charged, without touching either of them, a spark will be seen at each end of it, and it will, by the passage of the electric fluid through it, be either melted or become red hot. But if a needle be joined to the end of the wire, which is nearest to the inside of the jar, and be brought into contact with it, *no spark* is seen *at the entrance* of the fluid into the wire, yet the *same effects* are produced, as when the spark was visible.—

Nor will the pointed Conductors have any advantage over blunted ones, in drawing off the charge *gradually*, if they perform that operation *suddenly*, according to the ingenious experiment of Dr. Franklin, made with a prime Conductor ten feet in length, and one in diameter ; which gave rise to his theory of drawing the lightning from the clouds. As it is an experiment very applicable to this question, I shall here relate it in his words : “ Let a person, “ standing on the floor, present the point of a needle “ at twelve or more inches distance from it ; and “ while the needle is so presented, the Conductor “ cannot be charged, the point drawing off the fire “ as fast as it is thrown on by the electrical globe. “ Let it be charged, and then present the point at “ the same distance, and it will *suddenly* be discharged.”

* Dr. Franklin, in another part, gives us the following experiment : “ † An eye so situated as to “ view

* Franklin's Exp. p. 63.

† Ib. p. 126.

“ view horizontally the under side of a thunder-
 “ cloud, will see it very ragged, with a number of
 “ separate fragments, or petty clouds, one under
 “ another, the lowest sometimes not far from the
 “ earth. These, as so many stepping-stones, assist
 “ in conducting a stroke between the cloud and a
 “ building. To represent these by an experiment;
 “ take two or three locks of fine loose cotton, connect
 “ one of them with the prime Conductor by a fine
 “ thread of two inches, (which may be spun out of
 “ the same lock by the fingers) another to that, and
 “ the third to the second by like threads — Turn
 “ the globe, and you will see these locks extend
 “ themselves towards the table, (as the lower small
 “ clouds do towards the earth) being attracted by
 “ it; but on presenting a sharp point erect under
 “ the lowest, it will shrink up to the second, the
 “ second to the first, and all together to the prime
 “ Conductor, where they will continue as long as
 “ the point continues under them. May not, in
 “ like manner, the small electrified clouds, whose
 “ equilibrium with the earth is soon restored by the
 “ point, rise up to the main body, and by that
 “ means occasion so large a vacancy, as that the
 “ grand cloud cannot strike in that place?”

If the clouds ever happen to be circumstanced, as
 the locks of cotton and the prime Conductor are
 here described to be, the effects of the pointed Con-
 ductors upon them will probably be similar to those
 produced on the cotton in the experiment; one cir-
 cumstance however in the experiment seems mate-
 rially to differ from the great process of nature, in
 imitation

imitation of which it is made.—*The large or principal cloud* is, in this experiment, represented by the *prime Conductor*, which is a solid body having a *fixed* place in the apparatus, and consequently *incapable of moving* towards the point, as the loose locks of cotton do: But the *clouds* are composed of a *fluid* matter, *moving with the utmost facility* in another fluid substance, viz. the air, and are subject *to change their forms and situations* in the atmosphere with great rapidity, accordingly as they are affected by different causes: It does not therefore appear from any part of the experiment, that when the lower and more detached clouds have given out their electric contents to the pointed Conductors, the upper and principal cloud will not extend itself towards them, in order to discharge its electric contents into them, according to the constant law, that bodies containing an excess of the electric fluid, whenever they are at liberty to move freely, will accede to other bodies in which there is a comparative deficiency of the same fluid.

And indeed, if we were certain that the effect of pointed Conductors was similar to what is seen in the experiment, when the clouds happen to impend over buildings in that detached form; yet clouds often are in other forms, so that they are differently circumstanced, and then no such advantage can be supposed to ensue.

Clouds of an immense size are often in one united mass; buildings, and frequently whole cities are totally immersed in such clouds, whilst they are replete with lightning. Various instances of this kind

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are

are related by the learned Beccaria, and I have myself seen many such. On the 22d of March, 1772, I observed from my window, which is situated on the west side of the Thames, a large thunder cloud, which extended itself over the hills in Surry, south of London; the nearest part appearing about six miles from thence; at the same time the sky between that cloud and London was extremely clear, but in a few minutes after my observing the cloud at that distance, it approached the city, which immediately afterwards became immersed in it. At the same time there fell a heavy rain, and lightning appeared to proceed from the south-east towards the town. During the time of this storm I continued to observe, from my window, St. Paul's church, but could not perceive that the lightning directed itself particularly towards that building, which, as well as the rest of the town, was entirely surrounded by the cloud. — I shall hereafter mention the effects which were then produced on the Conductors of that church. If Conductors were capable of exhausting clouds charged with lightning of their contents, *that* would have taken place in the storm I have here mentioned; but notwithstanding the numerous Conductors through which part of the lightning was constantly passing, yet the flashes continued to succeed each other with undiminished force for a considerable time, as they frequently do in thunder-storms, so as to deprive us of all hopes of exhausting the lightning either contained in such immense masses, or passing through them to or from
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the earth and the buildings, and other objects on its surface.

Dr. Priestley observes from Beccaria, that he found*, “from his observations of the lightning abroad, and his apparatus within, that the quantity of electric matter, in an usual storm of thunder, is *almost inconceivably great*, considering how many *pointed* bodies, as trees, spires, &c. are *perpetually drawing it off*, and what a prodigious quantity is repeatedly discharged to or from the earth.

“Considering the *vast quantity* of electric fire that appears in the *most simple* thunder storms, he thinks it impossible that any cloud, or number of clouds, should ever contain it all, so as either to discharge or receive it.—Besides, during the progress and increase of the storm, *though the lightning frequently struck to the earth, the same clouds were the next moment ready to make a still greater discharge*, and his apparatus continued to be as much affected as ever.”

I think it evidently appears from these facts, that the quantity of lightning, which can be drawn from large thunder clouds by means of Conductors, is so very small a part of the whole contained in them, that any attempt to exhaust them must be looked upon as altogether vain.

This being established, it will be necessary, in the next place, to consider the manner in which lightning affects Conductors, even those which are constructed with the greatest care.

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* Priestley's Hist. Electric. p. 344.

In answer to your paper against pointed Conductors, published in the *Philos. Trans. Ann.* 1764, Dr. * Priestley quotes from Beccaria the following passage; "that no metallic apparatus can attract more lightning than it can conduct." This however is directly contrary to experience, for metallic bodies, not properly communicating with the earth, are frequently found to receive (or attract) a sufficient quantity of lightning to heat, melt, or even dissipate them; thus, swords, watches, &c. and metallic parts of buildings, are often injured, though they certainly receive a less quantity of lightning than bodies which communicate with the earth, the resistance in the latter case being less.

Whenever a metallic Conductor is interposed between any two bodies, differing greatly from each other in their quantities of the electric fluid, it will pass with great violence through the Conductor, in order to produce an equilibrium: If the metallic rods are not thick enough to conduct this quantity properly, they will, according to their proportional deficiency, either be destroyed, or will communicate violent effects to such bodies as are in contact with, or near, them.

The greatest quantity of the fluid hitherto collected in electrical experiments is infinitely less than that which passes from thunder clouds to the earth, and yet a quantity, far short of what may be so obtained, is sufficient to melt small wires, although as free a channel is given to it, as the smallness of the wire can afford.—When the wire is too large to be melted.

* Priestley *Hist. Elect.* p. 406.

melted by the passage of the fluid through it, but too small to convey it with ease, very violent effects are produced on such bodies as are in contact with it, or placed near it; for such bodies will be torn to pieces, burnt, or otherwise violently acted upon.

I shall here quote from Dr. Priestley some experiments which he mentions on this occasion, relative to what he calls, the *lateral force of electric explosions*,* which force was, I believe, first discovered by you, and published in your Treatise on Electricity, in the year 1750.† The *effects of this lateral explosion* he thus describes: “ I laid a green leaf upon
“ the palm of my hand, intending to make the explosion pass over the leaf; but the leaf was *burst*
“ and *torn to pieces*, and the explosion passing over
“ my hand, gave it a *violent jar*, the effects of
“ which remained in a kind of tingling for some
“ time.

“ Lastly, in order to judge the most perfectly of
“ this force, I laid a chain, communicating with
“ the outside of the battery, upon my naked arm
“ above the wrist, and bringing the discharging rod
“ near the flesh, within about two inches and a
“ half of the chain, I made the explosion pass over
“ that quantity of the surface of the skin.”

The effects of this explosion were, “ the hairs
“ upon the skin were all *singed, and curled up along*
“ *the whole path of the explosion, and for the space of*
“ *about an inch on each side of it*; also the papillæ
“ pyramidales of the skin were raised as when a
“ person

* Priestley's Hist. Elec. addit. p. 44.

† Vide p. 89, and the Plate III. fig. 9.

“ person is shivering with cold. *This was also the*
 “ *case in every part of the arm which the chain touched,*
 “ *and even that part of it which was not in the circuit.*
 “ Both the path of the explosion, and the place on
 “ which the chain had lain, had a redness, which
 “ remained till the next day. Sometimes the flesh
 “ has contracted a blackness by this experiment,
 “ which has remained a few hours.”

In electrical experiments the common, and most
 commodious, method of obtaining a large excess of
 the electric fluid in one place, and a large defect of
 it in another, is by the Leyden Experiment; but an
 equal excess and defect may be obtained in two sepa-
 rate non electric bodies if they are sufficiently large,
 and one of them be electrified positively the other ne-
 gatively. And by such an experiment we may sud-
 denly convey the contents of the body charged posi-
 tively, into that which is electrified negatively, and
 so produce, in the Conductor, &c. effects equal to
 those of the Leyden Experiment.

But tho' the bulk of the bodies, required to per-
 form such an experiment, renders it inconvenient to
 us, the process is such as nature frequently performs,
 with this difference only, that the quantity often
 ready to be discharged from the clouds into the
 earth, through metallic Conductors or parts of build-
 ings, is infinitely greater in proportion to those Con-
 ductors, than the largest charges of our apparatus
 are to the small wires which they are capable of
 affecting.

Let us suppose that several large metallic rods
 were placed as Conductors, to a magazine of gun-
 powder.

powder, and that the lightning was discharged from the clouds to the earth through them, in a quantity proportionably greater than that which passed thro' the wire and chain in Dr. Priestley's experiment, which is an imitation in miniature of the infinitely greater quantities of lightning discharged from the clouds through Conductors: would not the effects of tearing to pieces and burning have been produced by the Conductors in the magazine, in the same manner, and from the *same causes*, that affected the green leaf, hair, and skin, in the experiment performed in miniature? and would not the lateral force of this natural discharge extend itself to a proportionably greater distance from such Conductors, to several feet distance quite round them, if an overcharge of lightning passed through them?

Nor need we rely on reasonings taken from electrical experiments only.

If Conductors, purposely placed in buildings, were with care examined after every thunder storm, and authentic accounts of them given to the public, still greater lights might probably be thrown upon this matter.

The effects produced on the Conductors of St. Paul's, by the first considerable storm of lightning, which happened after they had been placed there, with the utmost care and consideration, by the committee appointed by the Royal Society, at the desire of the dean and chapter of that church, afford a remarkable instance, that such a *lateral force* takes place in the *largest Conductors* which have as yet been employed.

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The Conductors of St. Paul's were examined with great attention by Mr. Richard Gould, one of the vergers of that cathedral, on the 23d of March 1772, the day after the lightning had passed through them: As the letter he wrote to you contains some interesting and curious facts, of the truth of which we were witnesses; and as this paper, together with others on the same subject, though laid before the Royal Society, have not been thought proper to be published, it is necessary for me to mention here some of those facts, as they greatly illustrate what I have advanced in regard to the danger from a lateral force in particular situations.

Some of these Conductors appeared to have undergone a considerable violence by the passage of the lightning through them, insomuch that a thick rust, which was formed on their surface, was, by the lateral force, *beaten off, and removed to some distance* from them: The iron bars themselves had, for many feet, the appearance of having been *beated red hot*, resembling iron newly taken from a smith's forge: in other parts, the iron, as well as the stones near it, *was blackened by smoke.* —————

These bars seem to have undergone nearly the same violence as the wire and chain in Dr. Priestley's experiments, which I have before mentioned, with this difference only, that as the size of the Conductors greatly exceed that of the wire and chain, so did the quantity of electric fluid, which passed through them. It is probable that a greater thunder storm may at some future time produce still more violent effects on them: those already observed would

would have proved fatal, had the bars been placed in a magazine of gunpowder, instead of being contiguous to stone or other incombustible materials.

I have been informed that there are some curious particulars, relative to this subject, contained in a paper lately communicated in writing to the Royal Society, at its desire, by Dr. W. Hunter a respectable member of it, but as it is not ordered to be printed, and as on searching the journals of the Society, I find that no minute has been made of this paper, I cannot be sufficiently informed of the particulars to refer to them.

I cannot help regretting that such accounts are not thought worthy of publication, as it is only from a sufficient number of well attested facts, that this part of science, hitherto so little understood, can have sufficient light thrown upon it.

It appears evidently, that lightning produces very violent effects in passing through even those Conductors, which are constructed with the greatest caution, and which are contrived to carry it off without inviting it.—And it must be admitted that such conductors, if pointed at the top or elevated above the building, would facilitate the entrance of a much greater quantity, and consequently more violent effects would thereby be produced.

It also appears that the largest metallic rods, even when pointed, are incapable of exhausting large clouds of their electrical contents.

But although our Conductors are inadequate to so great a power, as that which is necessary to exhaust clouds of an immense size; yet they may be

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applied

applied with great probability of success, to carry off with safety as much lightning as may at any given time be contained in the metallic parts of a building, provided a complete communication be formed between them and sufficiently large Conductors.

In a building, those parts which are capable of being charged with lightning, may be *measured or estimated*, and consequently such Conductors may be applied to them, as, from their *size and construction*, are adapted to carry off that *given quantity*: but as we *cannot measure or estimate* the quantity of lightning, which may at any given time be contained *in the clouds*; so it is impossible to determine what quantity will, at any time, pass through such Conductors as are pointed and elevated above buildings, on purpose to facilitate its entrance.

I cannot determine what degree of success has attended the use of pointed and elevated Conductors, during the small number of years that they have been erected; as the only particular accounts of them, which I have met with in the publications of Dr. Franklin, as well as in the papers received by the Royal Society and others, relate merely to such Conductors as have been *unsuccessful, their points having been melted*, and the houses, &c. to which they were applied, having *been injured*: — But it is with great pleasure that I find, from a passage in Dr. Franklin's letters, that he agrees with us in opinion, that Conductors, which are *not pointed at the top*, nor *elevated above the roof*, and which are *sufficiently large*, and properly connected with each other, have *without any exception* been constantly found

found successful for many ages past : The following is the passage which I refer to : " Buildings that
 " have their roofs covered with lead, or other *me-*
 " *tal*, and *spouts of metal* continued from the roof
 " into the ground to carry off the water, are *never*
 " *hurt* by lightning, as whenever it falls on *such a*
 " *building*, it passes in the metals and not in the
 " walls." *

I cannot help expressing my regret, that our conclusions differ from those of Dr. Franklin, and others who have wrote on this subject, though drawn principally from the same experiments. I have in the course of this letter fully explained the reasons on which my opinion is grounded ; but shall attend with the greatest deference to such arguments as may be brought against it.

I am,

Sir,

Your sincere friend,

and humble servant,

Cotton Garden,
 Westminster,
 Feb. 20, 1773.

Edward Hufley Delaval.

* Franklin's lett. p. 481.

A P P E N D I X.

The very extraordinary effects of lightning upon the *iron bar* in *Martinico*, (mentioned in page 15.) being attended with a remarkable circumstance, it may be worth our while to make some observations upon it.

THIS bar was not only *reduced* to the *thickness* of a *slender wire* at the end next the wall, but, what deserves more particular attention, there was a *gradual diminution* to that part of the bar for more than *one foot*, as *Captain Dibden* informed me.

This *singular effect*, I apprehend, depended upon a *very great accumulation of the lightning* at that instant in the bar; which was caused by a *certain force that opposed its passage*, proceeding from the nature of the wall *where the iron terminated*, and where the *greatest accumulation* of that fluid must necessarily have

have happened ; as must *the least accumulation* at the *greatest distance* from that end. Hence we see the reason, why the effect upon the iron ought to be less and less, in proportion to the distance from the wall.

For wherever there is an accumulation of the electric fluid, there is always a force acting against it, to *occasion that effect* ; which is also true in regard to lightning. And that an accumulation does take place, in consequence of a force which is exerted *in* all bodies, or *at* their surfaces, may be collected from *every electrical experiment* : but in none more clearly, than where a great quantity of this fluid is discharged with violence through distinct pieces of metal in particular circumstances*.

For if the experiment is made with a chain, properly suspended, those parts of the links that appear to be in contact with each other, are instantly melted by the violent action of the fluid, in its endeavouring to pass from one link to the other, while the other parts remain firm and entire.

Similar to the above appearances, are those, where rods, or other small pieces of metal, lie so near to each other, that they are commonly said to touch. For at those parts, where there is an imperfect contact after the experiment is over, we frequently observe appearances of their having been melted : and, in some cases we are able to trace the marks of a
more:

* Among many instances, of this kind, is one which happened in March last, at a chapel in *Tottenham Court road*, on the same day and hour, (if not exactly at the same moment) that St. Paul's church was struck ; the account of which was given to the Royal Society by Mr. Henley.

more violent effect: such as a sudden diffipation of some part of the metal.

There is one observation that perhaps is not of the least importance; it is this, I am very apprehensive, that unless the *utmost attention is paid to this resisting principle in all cases*, the conclusions drawn from our experiments cannot always be depended upon.

What I mean by this *resisting force*, that acts so powerfully against the attacks of lightning, and the electric fluid, is explained in the experiments and observations I made many years ago; and which were afterwards republished in a more systematical manner, with additional observations by Dr. Hoadly and myself. It may not however be improper, in this Appendix, to insert some of them; and likewise some observations of the like nature, which I made, and published in a letter to *Epinus*, professor at Petersburg: as I hope they will contribute to make the philosophical part of this publication better understood, by those who may have inclination and leizure to consider them.

The late *event*, which happened to the Conductors in St. Paul's cathedral, affords us a remarkable instance of the powerful effects of lightning, in consequence of the above resisting principle.

I chose therefore to hang that fact out, as the most extraordinary, and capital experiment produced by the power of lightning, which has hitherto come to our knowledge: and I make no doubt, but that the ablest electricians in Europe will entertain the same opinion: when they consider the *quantity of metal*

metal heated in that experiment : the particular situations of that quantity, compared with the nature of the circumstances that opposed the passage of the lightning at those parts only, which have been already described.

What shall we say then to papers, containing such extraordinary facts, being rejected, and withheld from publication, by the influence of any?—

I cannot account for it any otherwise, than that it contradicted certain doctrines, which, of late years, have perhaps been too implicitly subscribed to.

The fact itself indeed, was little attended to at the time, except by Mr. Delaval and myself, who, on receiving information of those effects from Mr. Richard Gould, examined into the particulars within a week after the storm happened.

Some other gentlemen of the Royal Society, about three weeks after the event, visited those Conductors also. But as, during that interval, great quantities of rain had fallen for many days together, and the iron part of the Conductors were exposed to the weather, the greatest part of the rust, which was thrown off, and the black appearances upon the stone, &c. must have been washed away: and the surface of the iron itself must also have undergone some alteration, from the action of the air and water upon it, by forming afresh another, though thinner, coat of rust.

This remark is apprehended to be the more necessary, because I am informed, that those gentlemen,

men, who visited the church at that period of time, did not find the appearances so strong as we did. But however this may be, I can safely affirm, that even after an interval of nine months at least from the time the storm happened, the parts of the large iron bars, which were affected by the lightning, as hath been described, were conspicuously different from the other parts of the same bars, which did not suffer that violence.

Hoadly and Wilson, p. 53, &c. *

THUS have we seen, that the variety in the resistances made by different bodies to being electrified, have led us into the knowledge why bodies act so differently in one situation, from what they do in another, according to the nature, shape, and quantity of the bodies they are contiguous to
* * * * *

This our success in pursuing this train of reasoning is surely sufficient to encourage us to enquire farther, where this resistance is exerted, and from what power within the body it arises.

Now from our knowing by experiment, that every body more or less resists being electrified; which is now allowed to mean, that every body resists the passage of the electrical fluid, either *into* them, or *out* of them, though some do it with a greater force than others, we may very reasonably conclude, that when the fluid is endeavouring to get into any body, the

* Observations on a series of Electrical Experiments, printed for Payne 1756.

the resistance it meets with is exerted at that particular surface, at which the attack is made : and when this fluid is endeavouring to get out of any body, the resistance it meets with is exerted at all its internal surfaces at once ; and if the force with which this fluid endeavours to get in, or out, is superior to the force which endeavours to keep it out or in, at any place, or physical point of any of its surfaces, it must make its way more easily there, and consequently will always pass that way either in or out.

And there is an appearance in glass that is exactly analogous to this, with regard to the reflection of the rays of light ; by which it is evident, that a pane of glass resists the entrance of light in at one surface ; and when it has got in, it as strongly resists its going out at the opposite surface, because at both these surfaces it reflects or drives off great numbers of rays, that without such resistance would have passed readily through the pane of glass.

It is likewise known, that the rays reflected thus back into the glass, upon their endeavour to get out, and returned again to the first surface through which they had once got, meet again with an equal resistance there to their passing out, and are many of them reflected into the glass again.

It is shewn farther by Sir Isaac Newton, that this force begins to exert itself on the rays of light *before they arrive into contact with either of these surfaces.*

And hence we have reason to believe, that the the resistance we have experimentally shewn to be

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made

made by all bodies against being electrified either *plus* or *minus*, is of the same nature with that which not only prevents the entrance and exit of the rays of light in glass, but throws them off with the same velocity, great as it is, with which they endeavour to get into it, or out of it; and therefore most probably arises from the same cause.

And consequently, that this resistance in bodies to being electrified, is exerted as the other is, *before the electrical fluid comes actually in contact with the surface of any body it endeavours to electrify.*

The experiments therefore in Sir Isaac's Optics serve greatly to confirm the opinion we have endeavoured to establish by electrical experiments, that every body resists the entrance and exit of this electric fluid; and that this *resistance* is exerted at *some distance before the fluid* that endeavours either to get in, or out, *arrives at the surface* where the endeavour is made.

Our next enquiry is, whence this power arises, that is thus exerted at the surfaces of bodies.

In order to answer this; we have seen, that whilst any body continues to be sensibly, or perceptibly, electrified, whether it be *plus* or *minus*, in any of the experiments made on them by art, there is an *atmosphere of the same kind of fluid*, which naturally belongs to, and is formed *round them, sufficiently strong to balance every power that endeavours to electrify them above a certain degree*: otherwise they might be electrified more and more *without limit.*

This

This atmosphere therefore, thus surrounding the surface of bodies, when artificial force electrifies them, is what resists their being electrified more; and when it absolutely prevents it, must be equally dense and powerful with that electrical fluid that flows from the excited tube or machine, which endeavours to force its way through these atmospheres into the bodies, in order to electrify them more.

In the ordinary and quiet manner in which the imperceptible works of the author of nature are carried on among the component particles of the gross bodies on or near the surface of the earth; this subtile, active, electrical fluid, which not only surrounds each gross body, but pervading its pores, surrounds every component particle of it, where it is not in absolute contact with its neighbouring component particle; this active fluid, I say, cannot be idle, but must be in action, though that action be imperceptible to our senses: and it must, in an imperceptible degree, be varying its condition in all the parts of bodies whatever, i. e. in our present way of expressing ourselves, be electrifying them *plus* or *minus*, though not so forcibly as to give sensible signs of it*.

We may therefore not unreasonably conclude, that all bodies whatever, in their natural situation, and

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all

* As these terms may not be understood by every one, it may be proper to observe, that there is a certain quantity of this fluid belonging to all bodies naturally; and whenever we *increase* that quantity in any substance by art, that body is said to be electrified *plus*. On the contrary, when we *reduce* the natural quantity of this fluid in any substance by art, that body is said to be electrified *minus*.

all the component particles, have surrounding their surfaces, not in absolute contact with other surfaces, an imperceptible atmosphere of elastic particles sufficient to balance the smaller force with which they are attacked ; every way similar to the perceptible atmospheres, at the surfaces of bodies electrified forcibly, either by art, or the violent explosions in nature.

In these atmospheres, which surround the surfaces of all bodies, is placed the power, which occasions the resistance found experimentally to be made against those bodies being electrified to a higher degree than they are naturally, before we attempt to electrify them perceptibly to our senses : and the power is the elasticity of this subtile electrical fluid, every where dispersed indeed, where gross bodies are out of the way, but likewise confined within bodies differently, according to their different situations and neighbourhood to other bodies.

And these atmospheres may be encreased, or diminished, to a certain degree, many ways by art ; and when this is done with violence, the natural contexture of the bodies is altered in proportion to the violence.

But to make it still plainer that the resistance to electrification is made at the surfaces of bodies, I will shew in the following very curious experiments, that the electrical fluid, in passing from one body to another will always take that way, in which it meets with the fewest surfaces to break through.

Let a *Leyden* bottle, that has a hook in its coating, be electrified and set down on glass, and left to
itself.

itself. Let one end of a clean chain (such an one as is commonly used for a jack, but rather lighter) be fixed on to the hook in the coating ; and let a person grasp the coating of the bottle with one hand, and with the other hand bring the other end of the chain, and his finger and thumb that holds it, at the same time into contact with the wire of the bottle. Here then are two ways offered for the electrical fluid to pass from the wire to the coating, either through the person or the chain : and if the links of the chain hang loosely on one another, it passes through the person, and he is shocked very nearly as much as if the chain was not there. But if the chain be stretched by any contrivance, so that its links are all brought nearer into contact with each other, the fluid will pass through the chain, and the person will feel no shock at all : and this will be the case, let the chain be ever so long.

Whence it follows, that the electric fluid does not always pass from one body to another by the shortest way, but, on the contrary, it will go about, and pass that way in which it meets with *least resistance*.

Now if the chain alone forms the communication between the wire and the coating of the bottle, and it is spread so on a table, that the links of it scarce seem to touch one another, there will not only be a spark seen on the approach of the end of the chain to the wire of the bottle ; but a number of them will appear very visibly when the experiment is made in the dark, *viz.* at every place where the links do not absolutely touch one another. But when the chain

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is stretched tight enough to have every link brought nearer into contact with its neighbouring links, there appears but one spark on bringing the end of the chain to the wire of the bottle ; the whole chain then forming one continued metal nearly.

By the appearance of these sparks, or their non-appearance, we judge whether the electrical fluid passes through the chain or no.

Now in these experiments we have seen, that when the links of the chain were loose, the person was shocked, and the fluid passed through him ; and that it did not pass likewise through the chain, appears from the experiment, because no such sparks appear between the links.

Whence we may fairly conclude, that the resistance made to the passage of the electrical fluid through the chain, arises from the *sum of the resistances* at the different surfaces of the links, it was to break it's way through in passing through the chain. Because when the links were forced nearer into contact with each other, and so the whole chain was made, as it were, one continued metal, this resistance is entirely taken off, the person is not at all affected on the discharge of the bottle, nor do any sparks appear between the links.

Now if the experiment be repeated in the following manner, this consequence will be still plainer. Let one end of a wire, even many times longer than the chain, be fastened to the hook at the coating of the bottle, as well as the chain, and let a person grasping the bottle, as before, bring the other ends of both the wire and the chain into contact with
the

the wire of the bottle, and let the links of the chain lie loose on the table; or let the chain not be stretched.

Here are plainly three ways the electrical fluid may pass on the discharge of the bottle, through the person, through the chain, or through the wire: and the event of the experiment shows, that it does not pass through the person, because he feels no shock; and that it does not pass through the chain, because no sparks are seen between the links; and therefore that it passes through the wire, where it must meet with but one surface to break through, viz. the surface at the end that is brought to the wire of the bottle, the other end of it being supposed to be in contact with the hook at the coating of the bottle.

I shall observe by the by, that no one, who had not made the experiment, would imagine with how much force the chain must be stretched before the experiment will answer, and the electrical fluid pass through it without producing a spark at any of the links, i. e. before the links can be brought sufficiently near in point of contact with each other: which one would naturally think their weight alone would be sufficient to do.

But it appears that their weight will not do this, but that some additional force, independent of themselves, or their weight, is required to bring them into a *nearer contact*. †

THESE

† Mr. Delaval made an experiment, which is very much to the present purpose. It is published along with many other very curious ones,

THESE last experiments are a strong confirmation of the *resisting principle*. However, we will endeavour to illustrate it farther by the following argument, which is founded upon some observations of Sir Isaac Newton's, respecting the pressure of convex glasses; and which I have taken from the letter to *Epinus*, mentioned in the 38th page.

When a *bladder* is well blown up, and secured properly, it will yield or give way, and change its form in that part against which any given pressure is exerted. And upon removing the pressure, the bladder will immediately recover its first form.

This yielding or giving way of the form, and then afterwards recovering it, proves an elastic substance existing within the bladder, and between the two sides where the pressure is employed.

In like manner, when two glass prisms, or the object glasses of two long telescopes press upon each other with their own weight only, philosophers know, by the phenomena of light, that they do not touch: and that there must be something between the glasses to keep them at a distance. They also know, by the like phenomena, that more pressing
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ones, upon the convertability of conducting substances into non-Conductors of the electric fluid, in the Phil. Trans. Vol. 51. p. 87.

“ Having dried a Piece of Portland stone, I found it conducted
“ perfectly well; but upon powdering and sealing it up in a glass
“ tube, in which was a wire at each end) it became a perfect re-
“ sistor or non-conductor like the *metallic calces*; which seems to
shew, that the resistance to the passage of the electric fluid may be
increased, by increasing the number of surfaces.

is required to bring them nearer to a contact; and that when the pressure is removed, they immediately recover their first distance.

Now this yielding, or giving way, and the recovery of the distance between the glasses, proves the existence of some *elastic substance* between them respectively. Since we find the effects of applying, and removing the pressure, exactly similar to the case with the bladder.

THIS is the *medium* then which gives rise to the resistance found in electric experiments.

For when a quantity of the electric fluid is forced into the apparatus, which supports the two balls, (mentioned in the preceding experiments) we should, from its elastic principle, expect it to pass out again immediately: whereas the fact is, that it passes out by slow degrees; and takes a considerable time in evacuating the apparatus. Some *power* therefore must hinder the fluid, at least, in some measure, from escaping: and that power therefore must be exerted at, or near, the surface of the body.

To say it is forced in, and *detained*, by an *attraction of the body*, will not answer the purpose; for the *power which is supposed to draw the fluid into it*, must certainly *be sufficient to hinder it from passing out*. Now, by the experiment, the fluid does pass out, though slowly: this *power* therefore which resists its passing out, can be no other than what arises from the *medium* we have proved to be spread upon the surfaces of bodies.

From all these observations and experiments we learn, that to make the safest and best Conductor, there

is a necessity to have it made of one entire piece of metal. But as such a construction may not be obtainable in all cases, especially when it happens to be of a considerable length, the several joinings of the pieces, which may be found wanting to complete the same, ought to be brought so close to each other, by screws or otherwise, as art can make them; that the *resistance* to the passage of lightning may be *diminished* as much as possible.

Extracts from letters published by Dr. FRANKLIN, in his Treatise on Electricity, p. 395, 396, and p. 416 to 419; and which are referred to in p. 11 of the preceding letter to Sir CHARLES FREDERICK.

Letter I. **A**T Mr. West's house, in Philadelphia,
 " the Conductor, extended in height
 " about nine feet and a half above a stack of chim-
 " neys, to which it was fixed, (though Mr. Kinnerley,
 " the author of this letter, and of some curious expe-
 " riments in Electricity, which are well known, sup-
 " poses three or four feet would have been sufficient.)
 " It was somewhat more than half an inch in dia-
 " meter in the thickest part, and tapering to the
 " upper end. The Conductor, from the lower end
 " of it to the earth, consisted of square iron nail-
 " rods, not much above a quarter of an inch thick;
 " connected together by interlinking joints. It ex-
 " tended down the cedar roof to the eaves; and
 " from thence down the wall of the house, four
 " story

“ story and a half to the pavement in Water-street,
 “ being fastened to the wall in several places by
 “ small iron hooks. The lower end was fixed to
 “ a ring, in the top of an iron stake that was drove
 “ about four or five feet into the ground.

“ The above-mentioned iron rod had a hole in
 “ the top of it about two inches deep, wherein
 “ was inserted a brass wire, about two lines thick,
 “ and, when first put there, about *ten inches long*,
 “ terminating in a very acute point, but now,
 “ (*after a stroke of lightning*) its whole length was
 “ *no more than seven inches and a half*, and *the top*
 “ *very blunt*: that some of the metal appeared to be
 “ missing, the slenderest part of the wire being, as
 “ he suspected, consumed into smoke. But some
 “ of it, where the wire was a little thicker, be-
 “ ing *only melted by the lightning, sunk down*, while
 “ in a *fluid state*, and formed a *rough irregular cap*,
 “ lower on one side than on the other, round the
 “ upper end of what remained, and *became inti-*
 “ *mately united therewith.*”

II. “ TO the outside of Mr. Raven’s chim-
 “ ney was fixed a large iron rod, several feet
 “ in length, reaching above the chimney; and at
 “ the top of this rod the *points were fixed*. From
 “ the lower end of this rod, a small brass wire was
 “ continued down to the top of another iron rod
 “ driven into the earth. On the ground floor, in
 “ the chimney, stood a gun, leaning against the
 “ back wall, nearly opposite to where the brass wire
 “ came down on the outside. The lightning fell
 “ upon the points; did no damage to the rod they

" were fixed to ; but the brass wire, all down till it
 " came opposite to the top of the gun-barrel, was de-
 " stroyed. There the lightning *made a hole through the*
 " *wall, or back of the chimney, to get to the gun-barrel,*
 " down which it seems to have passed ; and although
 " it did not hurt the barrel, it damaged the butt of
 " the stock, and *blew up some bricks of the hearth.*
 " The *brass wire below the hole in the wall remained*
 " *good.*"

III. Mr. MAINE, of Indian Land, South
 Carolina, in a letter, dated Aug. 28, 1760, ac-
 quaints us, " that he had a *set of electrical points,*
 " consisting of *three prongs, of large brass wire, tipped*
 " with silver, and *perfectly sharp,* each about seven
 " inches long : these were rivetted into an *iron nut,*
 " about *three quarters of an inch square,* and opened
 " at top equally to the distance of *six or seven inches,*
 " *from point to point, in a regular triangle.* This
 " nut was screwed very tight to the top of an *iron*
 " *rod, of above half an inch diameter,* or the thick-
 " nesses of a common curtain rod, composed of several
 " joints, annexed by hooks turned at the end of
 " each joint, and the whole fixed to the chimney
 " of his house by iron staples. The points were
 " elevated six or seven inches above the top of the
 " chimney ; and the lower joint sunk three feet in
 " the earth, in a perpendicular direction. The light-
 " ning broke with a violent explosion on the chimney,
 " *cut the rod square off, just under the nut, and, he was*
 " *persuaded, melted the points, nut, and top of the*
 " *rod, entirely up ; as after the most diligent search,*
 " *nothing of either was found, and the top of the*
 " *remaining*

“ remaining red was cased over with a congealed
 “ solder. The lightning ran down the rod, starting al-
 “ most all the staples, and unhooking the joints, with-
 “ out affecting the rod, except on the inside of each hook,
 “ where the joints were coupled, the surface of which was
 “ melted, and left as cased over with congealed solder. No
 “ part of the chimney was damaged, only at the foun-
 “ dation, where it was shattered almost quite round,
 “ and several bricks were torn out. Considerable cavi-
 “ ties were made in the earth quite round the founda-
 “ tion, but most within eight or nine inches of the rod.
 “ It also shattered the bottom weather-board, at one
 “ corner of the house, and made a large hole in the
 “ earth, by the corner post. On the other side of
 “ the chimney, it ploughed up several furrows in the
 “ earth some yards in length. It tore up the hearth in
 “ several places. A copper tea-kettle, standing in the
 “ chimney, was beat together, as if some great
 “ weight had fallen upon it; and three holes, each
 “ about half an inch in diameter, melted through the
 “ bottom.” What seemed the most surprising to Mr.
 Maine was, that “ the hearth, under the tea-kettle,
 “ was not hurt: yet the bottom of the kettle was
 “ drove inward, as if the lightning proceeded from
 “ under it upwards, and the cover was thrown to
 “ the middle of the floor, &c. &c. ——— The
 “ kitchen, at ninety feet distance, was full of negroes,
 “ who were all sensible of the shock; and some of them
 “ told him, that they felt the rod about a minute
 “ after, when it was so hot that they could not bear
 “ it in hand.”

It may not be improper here to observe, that con-
 sidering the very many difficulties there are in coming
 at

at any facts, particularly philosophical ones, when they happen in remote countries, as in America, and even in England; it is rather extraordinary to find *three cases* published by Dr. Franklin himself, where the *pointed parts* of his Conductors, &c. and the buildings they were applied to, were injured by lightning. I make no doubt but that there are many other instances, in obscure places, which have passed unnoticed. For all men are not philosophers: and those who may delight in observing curious appearances have not always inclination or opportunity to make them public. There is indeed one instance more from *America*, where the pointed part of a Conductor was also melted: the account of which was lately communicated to the Royal Society.

William Lyttelton, Esq; who was Governor of South Carolina some years ago, remembers a storm of lightning that fell upon a stable which belonged to him, whilst he resided there: though his house, which was provided with one of those pointed Conductors, was distant from the stable but about twenty yards; nevertheless two of the rafters of the stable were split and thrown down by it. To these accounts I shall soon have another to add respecting a house which was *greatly damaged* by a stroke of lightning; notwithstanding it was also provided with a *pointed Conductor*.

I shall now put a few questions, that may be of use in some future observations, which I propose to make at some convenient time, upon the *three letters* quoted from Dr. Franklin, as well as upon his remarks at the end of Mr. Maine's letter.

QUESTIONS.

QUESTIONS.

1. Does the house of Mr. Maine stand upon high or low ground ?
2. What is the nature of that ground ?
3. Is it generally dry or moist ?
4. Are there any rivers, ponds, or other waters near it ?
5. Are there many other buildings near Mr. Maine's house ? and what may be the nearest distance of any one of them ?
6. What are their heights compared with Mr. Maine's ?
7. Whether any of those buildings were provided with Conductors at the time the lightning happened ?
8. Were those Conductors circumstanced as Mr. Maine's Conductor was, in point of elevation, &c. and with *three prongs equally sharp* ?
9. Were any observations made upon those neighbouring Conductors, when that of Mr. Maine's was attacked ?
10. Are the persons, who have pointed Conductors to their houses, provided with a *stock of sharp points*, for the purpose of *replacing those that may be destroyed by lightning* ?
11. Whether a *Mr. Peroneau*, of Charles-Town, in South Carolina, had not his house *greatly damaged* by a stroke of lightning, notwithstanding it was provided with a *pointed Conductor* ? when did that event happen ? and what were the circumstances that attended it ?
12. And

12. And whether there are not several other instances in America, which are well known to many, where the lightning has been found to damage the pointed Conductors, or the buildings they were affixed to, or both, at the same time?

I SHALL sum up the whole of this subject with a few *general observations* on the method of securing buildings from the effects of lightning.

1. Buildings made of *Fir* entirely, having no metal for the fastnings, ornaments, or conveniencies, are the least liable to be attacked by lightning.
2. Buildings that have more or less metal in their construction, &c. or in which the metal is more or less connected together, are more or less liable to be attacked. The metal, together with the disposition of it in the buildings, being the inducement for the lightning to enter; and the obstruction made to its passage by the other neighbouring materials being generally the cause of its dangerous effects, in tearing and dashing them to pieces.
3. It has therefore been found necessary, to connect those metals, by others, from the top of the building to the bottom, and to moist ground below it.
4. But as it may be difficult, in many cases, to make such a connection properly, bars of iron, or leaden spouts, extending from the top of the building to the moist ground, may be fixed with more ease, and perhaps with less expence. However, such Conductors will have an advantage over the
the

the other method, by answering the purpose of conveying away the lightning more safely, *when-ever it chanches to attack them.*

5. *Sharp points* fixed upon such Conductors are dangerous: for as the lightning is found to act with more power upon them than upon *blunted ends*, in the proportion of at least twelve to one, it seems to me, that they are put there only to *invite an enemy* which otherwise might not have troubled us; and of which we can by no art discover the whole power: and should any extraordinary accumulation of this active matter, be at any time effected in a Conductor, by means of so very easy a passage as is furnished by a *point*, there is no saying what the consequences may be. And that clouds sometimes are able to furnish such extraordinary accumulations of lightning, and for a considerable time together, even after many violent explosions, there are innumerable instances. Among others I remember to have seen in Yorkshire, some years ago, between nine and ten in the evening, a very large black cloud, which occasioned prodigious quantities of lightning, and almost incessantly, for a considerable time together; half an hour at least. But what is more remarkable, the course of this black cloud was traced from the South-West of England to the North, or North-East, of Scotland, and even into Sweden; *causing very great lightnings* as it past over part, if not the whole land, in that direction. When it passed over London, which was about twelve

at noon, the same day on which it was seen in Yorkshire, a darkness accompanied it, like that of an eclipse, for a considerable time. And that this cloud was the same which Professor Bergman observed in Sweden, was collected from the different times it was observed, at different places, corresponding with its velocity.

N. B. SINCE the printing of the facts in the preceding papers, respecting the Conductors belonging to St. Paul's cathedral, the committee have met and examined them, in all the parts which they could conveniently come at; when certain defects in the construction of them appearing, the committee thought it highly necessary they should be rectified directly, together with every other defect, which, upon a more particular examination, might be discovered: and those their thoughts were accordingly reported to the Dean and Chapter.

Extracts from authentic papers, giving an account of of two Magazines of Gunpowder that were supposed to be blowu up by Lightning: one of them being in Brescia, a large City in the Territories of Venice; the other at Fort Augusta in Jamaica.

Papers relating to the Magazine at Brescia.

HAVING read some *extraordinary accounts* in our daily and monthly publications, of a powder magazine that had been blown up by lightning, at *Brescia*, in August 1769, I applied to the Venetian Ambassador

Ambassador to procure me the honour of an answer to some *questions* which I drew up from the hints collected in the public papers: with a view to come at the knowledge of such facts as I apprehended were material, and might be depended upon. I was the more induced to take this step, as I was, about the time of writing the *questions*, engaged in drawing up a *report*, which required every information I could obtain, respecting accidents by lightning.

The Questions proposed were as follow :

1. Whether the magazine of powder was lodged in a bastion? and if so, what was the height of that bastion compared with the ground round about it?
2. What kind of materials covered the magazine?
3. And whether such covering was bomb proof?
4. Whether any buildings were in the neighbourhood of the bastion? and at what distance?
5. Whether there was any iron or other metal; and what quantity of it, over, or upon, the bastion?
6. What was the quantity of powder lodged in the magazine at the time of the explosion? and whether *all* the powder was exploded at the time it happened?
7. Whether the blowing up was occasioned by a flash of lightning?
8. To what distance were the largest stones, or other materials thrown?

9. What number of houses in general were destroyed by it? and what number of churches or other large edifices?
10. What was the greatest distance at which houses were damaged?
11. What were the kind of fastenings, said to be of the strongest nature, that were forced at eighteen miles distance? and if not to that distance, to what other distance were those effects observed to take place?
12. Whether any stone bridges were thrown down by the explosion?
13. What was the greatest distance at which the effects were perceived?
14. Whether any cannon were removed from their places, and to what distance? and if any were, how were they circumstanced in point of situation, &c.

From VENICE, by the Favour of ———.

Reponse aux questions relatives a l'explosion de la tour, &c.

A la premiere. Il n'est pas question de magasin à poudre. C'étoit une ancienne tour de 20 toises de hauteur sur 6 de largeur; batie et revetue de pierres de taille fort grosses: dans laquelle par une grande mégarde on avoit mis 400 livres de poudre. Cette tour étoit placée à la porte meridionale de la ville au dedans des remparts; voici pour la seconde et troisième question aussi.

A la

A la quatrième. Il y avoit des batimens à très peu de distance tant au dedans qu'au dehors de la ville. Les plus proches à quarante pas seulement.

A la cinquième. Dans la tour il y avoit quelque barre de fer, quelque grille dans la muraille. Point d'autre metal.

A la sixième. La quantité est marquée ci dessus.

A la septième. L'explosion fut occasionnée par un éclair.

A la huitième. A deux milles d'Italie les plus petites : les plus grosses à un mille, une pierre de 700 livres de poid tombant à un quart de mille de distance sur le comble d'une maison l'écrasa avec la mort de 7 personnes.

A la neuvième. Plus de 100 maisons détruites avec une petite église ; 200 autres maisons fort endommagées, avec plusieurs eglises. Presque toutes les autres maisons, eglises, et batimens de la ville ont ressenti le terrible effet de l'explosion de la tour, du moins pour la quantité prodigieuse des glaces, et des vitres cassées.

A la dixième. A la distance d'un demi mille d'Italie.

A la onzième. Quelque barre de fer et de bois fut jetée à la distance d'un quart de mille d'Italie.

A la douzième. Rien de celà.

A la treizième. Jusqu'à trente milles d'Italie. Il y eut aussi quelque petit tremblement jusqu'à cette distance dans les murailles des maisons, occasioné par l'explosion. On a amusé beaucoup
la

la credulité du public, avec des pretendus effets observés d'aussi loin ; mais on n'a pas imposé aux éclairés.

A la quatorzième. Deux petits canons seulement, placés à la porte de la ville proche de la tour à poudre, furent jettés dans le fossé à la distance de 60 pas.

A l'occasion de la funeste explosion de la tour on remarqua des phenomenes très singuliers, et j'ose dire incroyables à tous ceux, qui ne les ont pas observés de leurs propres yeux ; quoiqu'ils soient très certains. Par exemple il y eut des portes ouvertes d'une façon tout-à-fait extraordinaire ; comme la grande porte de l'église nommée la *Pace* placée à un tiers de mille de la tour, laquelle étoit fermée au dedans vers la partie supérieure par une grosse barre de fer, au milieu par un gros verrouil qui avoit sa ferrure, et vers l'extrémité par un plus petit verrouil avec la ferrure de même. Or quand l'explosion arriva, le terrible effort de l'air brisa le bois vers le milieu de la partie supérieure de la porte, et detacha la barre : à l'instant le petit verrouil à l'extrémité inférieure se plia au dedans, et sortit de deux anneaux sans sortir cependant de sa ferrure. Cela n'a rien d'extraordinaire ; mais le gros verrouil du milieu sortit pareillement de ses deux anneaux ne sortant pas de la ferrure, et ne se trouva nullement plié, ni endommagé en aucune façon. On observa soigneusement l'architrave, et le seuil de marche, de même que les murailles de la porte, et on ne vit ni elargissement, ni derangement de porte. Le même accident arriva à des autres portes plus petites,

petites, et on ne peut absolument l'expliquer d'une façon raisonnable. C'est aux sçavants Messieurs, qui ont proposé les questions, à tacher d'eclaircir un fait, qui n'est pas moins vrai, qu'incroyable.

The same Questions answered by another hand.

1. The magazine which blew up was erected on the rampart, close to the gate of *Santo Nazaro*, and was elevated about 40 feet from the level of the town.
2. The magazine was built of masonry, and of a square figure, whose exterior side did not exceed 30 feet; nor the thickness of the walls 6 feet; so that the area within did comprehend 324 superficial feet.
3. By observations made on many other square towers, similar to that blown up at the gate of *Santo Nazaro*; it may be supposed that although there was an arch made of masonry, which covered it, yet it was not so thick as to be able to resist the force of a 13 inch shell.
4. The distance from the gate of *Santo Nazaro*, to the nearest part of the town, was about 120 feet.
5. Iron bolts, and various straps of iron, strengthened the door of the magazine; therefore it naturally attracted to it the flashes of lightning.

6. From

6. From the construction of the square tower, (which was only a temporary deposit for gun-powder) I am sure it could not contain more than 1000 barrels (viz. 112 pounds in each barrel) if it had been full; but from what I could understand when at Brescia, there was not above half the quantity. The whole quantity of powder was certainly exploded.
7. No other cause has ever been assigned by the inhabitants of Brescia, for the blowing up of the magazine, than by lightning; as the explosion immediately succeeded a violent tempest of thunder and lightning.
8. Various have been the accounts to what distance the largest stones, and other materials, were thrown: some say to the distance of two miles; but I have seen stones to the size of three hundred weight laying at the distance of one thousand yards from the gate of *Santo Nazaro*, which have been declared to be part of the magazine blown up.
9. At the extremity of a radius of 1000 feet, forming and comprehending the third part of a circle; houses were totally destroyed, with all the inhabitants buried in the ruins. With precision I cannot tell the number of houses that were destroyed; but I suppose there were between two and three hundred. One church was totally demolished, and another was so effected by the explosion that it was intended to take it down. The Cardinal's Palace, at the distance of 1000 feet, built with masonry, was entirely ruined.

10. By

10. By the explosion many large stones of the magazine were thrown into different parts of the town, and broke through roofs and floors of houses and convents, and did considerable damage.
11. I never heard that fastenings of any kind, even within the town, had been forced by the explosion, much less at the distance of 18 miles.
12. No stone bridges were affected.
13. The explosion was felt at Bergamo, a town situated upon high ground; distant from Brescia about 30 Italian miles.
14. No cannon were moved from their places.

N. B. Without the gate of *Santo Nazaro*, a circular ravelin is built, which was much less affected by the explosion than one would imagine; yet it clearly shews, by the situation of the door, that the line of least resistance was towards the body of the place, although the whole mischief was done within the walls of the town; and I do verily believe, that the iron on the door of the magazine greatly contributed to attract the lightning to that part.

*Papers relating to the Magazine at Fort Augusta,
in Jamaica.*

S I R,

A Greeably to your request I have inspected my papers, and found, that on the 28th of September, 1763, I wrote a letter to Mr. Wellbore Ellis, then Secretary at War, dated at Spanish Town
I in

in Jamaica, by which I informed him that, "on
 " the 14th of that month an unhappy accident hap-
 " pened at Fort Augusta in that island; where a
 " magazine, containing 2850 barrels of gunpowder,
 " was blown up by lightning; and the explosion,
 " besides doing much damage to the Fort, killed four
 " officers, viz. Captain Talbot, Captain Lieutenant
 " Dunbar, and Ensign Keating, of the 43d regi-
 " ment; and Lieutenant Monfel of the 74th; and
 " eleven private men, and wounded seventy-six more
 " belonging to those two corps." I have no other paper
 or document relating to this matter, but I remem-
 ber that the explosion happened about nine or ten
 minutes, as computed, after some powder belonging
 to one of his majesty's ships had been placed in the
 magazine; and it was supposed that a train had been
 formed by some of that powder which might have
 fallen on the ground, from a flaw or crevice in one
 of the barrels which contained it. I am, with great
 regard,

S I R,

Mount-Street,
 Feb. 2, 1772.

Your most humble servant,

W. H. LYTELTON.

*Extract of a letter from ———, at ———,
 Kingston in Jamaica, Sept. 20, 1763.*

I AM extremely sorry to acquaint your ———
 with a most surprizing accident which happened
 here the 15th instant. The powder magazine at
 Musquito Point was then blown up (supposed by
 lightning)

lightning) wherein was contained all your ———'s powder under my charge; a particular account thereof I have herewith annexed; likewise all the powder of his majesty's ship Valiant was at that time lodged in the said magazine, and has shared the same fate.

Extract of a letter from ——— to ———, dated on board the ——— at Jamaica, Sept. 21, 1763.

I HAVE nothing particular to mention in addition to what I wrote by the Centaur, but the unlucky accident of the magazine at Fort Augusta, in Musquito Point, blowing up the 14th instant, with three thousand barrels of powder in it; by which three officers and about thirty private men were killed, and three officers and upwards of forty men wounded, and the fortification near the magazine much shaken. This accident, by most people that were in the Fort, is laid to the account of the lightning, but I cannot pretend to inform their ——— to what it was owing. The Valiant's whole sea-store of powder, near four hundred barrels, had the fate of the rest in the Fort.

ANOTHER account says, that when the magazine at Jamaica blew up, the centinel observed a large ball of fire in the air, directing its course towards the magazine; upon which he jumped from the rampart into some low ground, and was not hurt. That it was supposed the ball fell upon the center of the arch. That some barracks near the magazine

zine were thrown down, and part of the fortification destroyed. — That many of the copper hoops were found twisted together, and thrown to a great distance. That the windows were broke at seventeen miles distance. That the magazine being situated near the sea, great part of the hoops were supposed to have fallen therein.

E R R A T A.

<i>Page</i>	<i>Line</i>	<i>for</i>	<i>read</i>
11	5	happened.	happened ;
17	16	<i>possitively</i>	<i>positively</i>
18	5	effects	accidents
22	17	receive	occasion
48	24	convertability	convertibility
	29	resister	resister
52	18	Tnis	This

